

4.0 EXPOSURE ASSESSMENT

The stack emissions from the TOCDF and CAMDS combustion units were modeled to disperse downwind and deposit in the areas surrounding the facilities. The exposure assessment identifies the exposure scenarios in the assessment area and estimates the magnitude of exposure by human receptors to COPC emissions from the combustion units. An exposure scenario is a combination of exposure pathways to which a single “receptor” may be subjected (U.S. EPA 1998a). Human receptors come into contact with COPCs emitted from combustion sources to the atmosphere through both direct and indirect exposure routes. The direct routes are inhalation and dermal uptake, and the indirect route is by ingestion of water, soil, vegetation, and animal products that are contaminated by COPCs through the food chain. An exposure pathway consists of the following components:

- An exposure route
- A source and mechanism of COPC release
- A retention medium or a transport mechanism and subsequent retention medium in cases involving media transfer of COPCs
- A point of potential human contact with the contaminated medium

The exposure assessment assumes that individuals that inhabit or work in the assessment area will consume contaminated plants, livestock, and fish near DCD. The exposure assessment will be performed in accordance with U.S. EPA (1998a) guidance. The exposure assessment describes the exposure setting and land use, identifies receptors and exposure pathways, and estimates media concentrations and chemical intakes. Section 4.1 discusses the exposure setting characterization. Section 4.2 describes the exposure scenarios to be evaluated in the HHRA. Section 4.3 discusses the equations and calculations performed to estimate COPC concentrations in media.

4.1 EXPOSURE SETTING CHARACTERIZATION

The exposure setting focuses on identifying current and reasonable potential future human activities and land uses, which identify the exposure scenarios to be evaluated in the HHRA (U.S. EPA 1998a). The assessment area includes exposure scenarios inside and outside of the perimeter of the facility. The air dispersion modeling was performed out to a radius of 20 km. This distance is consistent with U.S. EPA (1998a) guidance, which indicates that modeling out to a radius of 10 km is sufficient to characterize

exposure scenario locations. For DCD, all recommended exposure scenarios are located within 20 km of the facility, including water bodies and their associated watersheds. Exposure scenarios inside the perimeter of the facility (“on-site”) will be evaluated in order to identify risks to workers and any limitations associated with any future use of the facility by the Army. The on-site area also includes facility and non-facility property because some areas may be rented to the public for farming, ranching, or recreational purposes. Current land use and the location of water bodies were also considered in the assessment.

4.1.1 Current and Potential Future Land Use

Current and reasonable potential future land uses were considered in characterizing the exposure setting. When combined with the air dispersion modeling results, these land uses define which exposure scenarios and locations will be evaluated in the HHRA (U.S. EPA 1998a). Reasonable potential future land use is also important because the HHRA will evaluate risks for a period of 30 or more years.

DCD is situated in the arid Rush Valley, which has approximately 375 residents (U.S. Census Bureau 2000). DCD is approximately 50 miles southwest of Salt Lake City (estimated population of 174,348), 20 miles south of the Tooele Army Depot (TEAD) and the city of Tooele (estimated population of 16,748), and 38 miles west of the city of Provo (estimated population of 110,419) (U.S. Census Bureau 2000). These metropolitan areas are located outside the 20-km assessment area. Cities in the assessment area, which also includes sparsely populated mountainous areas, include the town of St. John, approximately 3 miles northwest of DCD, the town of Faust, approximately 5 miles south of DCD, and the town of Clover, approximately 3 miles west of DCD. The small towns of Ophir and Gisborn are located in the Oquirrh Mountains approximately 4 miles northeast of DCD (U.S. Census Bureau 2000).

Ranches are interspersed throughout Rush Valley. The nearest ranch residences are located near the town of Ophir (DSHW 2000c).

The land surrounding DCD is primarily used for agriculture and farming, mainly as rangeland (Tetra Tech 2000b). Privately-owned parcels of land adjacent to DCD are used to graze cattle and sheep (ATK 1996; Tetra Tech 2000b). Most of the agricultural areas near DCD are located north and northwest of the facility near the town of St. John (see Figure 2-1). The primary crops in the area include

corn, wheat, and barley (ATK 1996). In addition, land along the northern boundary of DCD is irrigated and planted with alfalfa (DSHW 2000c).

The potential exposure to emissions from DCD will also be evaluated for exposure scenarios relevant to the city of Stockton, about 14 miles north of DCD. This area was a major smelting center in Utah starting in the 19th Century (U.S. EPA 1999a). The Jacobs Smelter, a National Priorities List Superfund site, was one of nine smelting centers that once operated in Tooele County (U.S. EPA 2000a). It operated from the late 1870s to around 1914 refining gold, silver, copper, lead, and zinc (U.S. EPA 1999b). UDEQ and the U.S. EPA have conducted numerous investigations throughout the surrounding residential areas, and have identified high concentrations of lead and arsenic in the soil (U.S. EPA 1999a).

To identify properly geo-referenced exposure scenario locations for current land use and indications of future land use, hard copies and electronic versions of land use land classification (LULC) maps, topographic maps, and aerial photographs will be reviewed. Selected exposure scenario locations will be geo-referenced with the ISCST3 grid nodes from the atmospheric dispersion modeling (Section 3). The UTM-coordinate system format (NAD27 or NAD83) for all mapping information will be verified to ensure consistency and prevent erroneous geo-referencing of locations and areas. The following are sources and general information associated with the data types or maps that will be reviewed to determine current and potential future land uses:

- **LULC Maps** LULC maps will be downloaded directly from the United States Geological Survey (USGS) web site (<http://mapping.usgs.gov/index.html>), at a scale of 1:250,000, in a file type GIRAS format. LULC maps may also be downloaded from the U.S. EPA web site (<ftp://ftp.epa.gov/pub>), at a scale of 1:250,000, in an Arc/Info export format. Exact boundaries of polygon land use area coverages, in areas being considered for evaluation, will be verified using available topographic maps and aerial photographic coverages.
- **Topographic Maps** Topographic maps are readily available in both hard copy and electronic format directly from USGS or numerous other vendors. These maps are commonly at a scale of 1:24,000, and in a file type TIFF format with a TIFF World File included for geo-referencing.
- **Aerial Photographs** Hard copy aerial photographs can be purchased directly from USGS in a variety of scales and coverages. Electronic format aerial photographs or Digital Ortho Quarter Quads (DOQQ) can also be purchased directly from USGS. Properly geo-referenced DOQQs covering a 3-km or more radius of the assessment area, overlays of the LULC map coverage, and the ISCST3 modeled receptor grid node array

provide excellent references for identifying land use areas and justifying the selection of exposure scenario locations.

Site-specific physiographic features of the DCD area may also be considered to provide a frame of reference for comparing default variable and associated assumptions applied in the fate and transport models.

4.1.2 Water Bodies and Associated Watersheds

The identification of surface water bodies and watersheds at different locations in the assessment area that receive deposition from emission sources will determine the potential for COPC exposures from the ingestion of fish, ingestion of drinking water, and incidental ingestion of surface water (U.S. EPA 1998a). Soldier Creek (which feeds Rush Lake) is a drinking water source for the town of Stockton (DSHW 2000c). The usage, surface area, and location of water bodies and their associated watersheds near DCD will be determined by reviewing LULC maps, topographic maps, and aerial photographs.

For water bodies identified as potentially impacted from TOCDF and CAMDS emissions, the areal extent of the associated watershed that contributes water to the water body will be identified and defined by UTM coordinates (U.S. EPA 1998a). The watershed determines overall water body COPC loading because pervious and impervious areas of the watershed and the soil concentration of COPCs resulting from emission sources are also used in the media concentration equations to calculate the water body COPC concentrations resulting from watershed runoff.

The following water body and watershed parameters will be identified and are necessary to determine COPC exposures from surface water in the DCD assessment area:

- Water body surface area
- Watershed surface area
- Impervious watershed area
- Average surface water volumetric flow rate
- Current velocity of surface water body

- Depth of surface water body column
- Universal Soil Loss Equation (USLE) rainfall/erosivity factor

The surface water system at DCD is composed of several perennial and intermittent streams, as well as one man-made reservoir. The most significant water body within facility boundaries is Rainbow Reservoir. Rainbow Reservoir is located in the northeast corner of the installation and has a capacity of 20 million gallons of water that covers an area of 3.5 acres (Tetra Tech 2000b). Historically, the reservoir was managed as a catch and keep program. However, the Army discontinued the program in 1994. Currently, no boating or swimming activities are allowed at Rainbow Reservoir. However, according to DCD's 2000 *Integrated Natural Resource Management Plan*, the reservoir may be stocked and opened to the public for recreational fishing (Tetra Tech 2000b). Therefore, Rainbow Reservoir will be evaluated as a source of potential risk through fish ingestion.

Rush Lake will also be evaluated in the HHRA as a water body that may potentially impact receptors near DCD. The lake is located about 19 km north of DCD (ATK 1996). The lake covers an area of 3,082 acres and is approximately 20 feet deep. Rush Lake will be assumed to support recreational activities, including fishing, sailing, and windsurfing (MRI 1999). There are also two small private water ski ponds located about 26 km west of DCD operated by SunTen Inc. (DSHW 2000c). The ponds are about 4.1 and 0.7 acres in size, each with an average depth of about four feet (Tetra Tech 2001). The ponds will be modeled as a single 4.8-acre pond. The potential risk from the incidental ingestion of surface water at the water ski ponds will be evaluated.

4.1.3 Special Sub-populations

Special sub-populations are defined as human receptors that may be potentially at higher risk due to receptor sensitivity to COPCs (e.g., elderly, infants and children, fetus of pregnant women) (U.S. EPA 1998a). Schools, day care centers, nursing homes, and hospitals located in the assessment area will be identified and evaluated qualitatively in the HHRA.

4.2 EXPOSURE SCENARIOS

The HHRA will quantify potential exposures using hypothetical exposure cases called receptors. The receptors are sets of assumptions that describe scenarios, but are not actual people and are unlikely to

apply to every single individual in Tooele County. The evaluation of a receptor will be performed at the maximum point of impact for emissions, which will be protective of other receptors in the area. This approach is protective because all other locations are assumed to have less exposure because impacts from emissions are lower. Therefore, every member of the potentially exposed population does not require quantification of risk.

Exposure scenarios that best characterize the human activities in the areas surrounding the emission sources were selected for evaluation in the HHRA (DSHW 1999c). Several factors were considered during the exposure scenarios selection process including EPA-recommended exposure scenarios; site-specific information including facility location, area topography, land uses (see Section 2.2.1); and DSHW-recommended exposure scenarios (DSHW 1999c). Based on these factors, revisions were made to the exposure scenarios recommended by U.S. EPA (1998a) to make the HHRA site-specific and relevant to the populace around DCD.

Section 4.2.1 summarizes EPA's recommended exposure scenarios, and Section 4.2.2 presents the exposure scenarios that will be evaluated in the HHRA, including rationales for excluding or including exposure scenarios based on site-specific information and DSHW objectives.

4.2.1 EPA Recommended Exposure Scenarios

U.S. EPA (1998a) recommends evaluating the following exposure scenarios in a combustion HHRA:

- Resident Adult
- Resident Child
- Farmer Adult
- Farmer Child
- Fisher Adult
- Fisher Child

The residential exposure scenario represents receptors in an urban or rural (nonfarm) setting. This scenario is recommended for evaluation because the ingestion of homegrown produce pathway has been shown to be potentially significant. This exposure is related to the bioaccumulation of COPCs up the

food chain. The farmer exposure scenario represents farming and ranching activities that may occur surrounding the facility. Indirect ingestion routes from farming practices may represent significant potential exposure to COPCs released from combustion sources. The subsistence fisher accounts for receptors exposed to COPCs in an urban or rural setting where fish is the main diet. Ingestion of fish is significant through the bioaccumulation of COPCs up the food chain. However, the HHRA will not evaluate the subsistence fisher scenario because DSHW has determined that there is no subsistence fishing in Tooele County.

4.2.2 Exposure Scenarios to Be Evaluated

Both current exposure pathways and potential future pathways, summarized in Table 4-1, will be evaluated for relevant exposure scenarios, which include the following:

- Resident adult and child
- Subsistence rancher and child
- Recreational adult and child
- On-site depot worker

The following sections discuss the pathways that will be evaluated for these exposure scenarios.

Available site-specific information, such as facility location, land use, and dietary habits, was taken into account during the selection process. Dermal exposure will not be evaluated because U.S. EPA (1998a) indicates it contributes insignificant risk compared to the ingestion and inhalation exposure routes.

Table 4-2 summarizes the rationales for selecting and the method for quantifying exposure pathways evaluated in the TOCDF HHRA. Note that the exposure assessment procedures support the assessment of exposure through default pathways recommended by U.S. EPA (1998a) as well as site-specific pathways relevant to receptors in Tooele County. For example, ingestion of homegrown cow's milk will be evaluated under the subsistence rancher scenario. Results of this pathway can be applied to a resident who may, in the future, consume homegrown cow's milk as a supplement to commercially purchased milk. However, the resident ingestion rate probably will be substantially less than that of the subsistence rancher. Thus, risk from ingestion of homegrown cow's milk by the subsistence rancher may be added to the risk from other resident pathways to determine the total risk to a resident that ingests homegrown cow's milk. While this method may overestimate risk (because it assumes higher exposure through

TABLE 4-1

EXPOSURE PATHWAYS FOR EMISSIONS FROM DESERET CHEMICAL DEPOT

Exposure Pathway	Type of Exposure	Resident Adult	Resident Child	On-Site Depot Worker	Recreational Adult	Recreational Child	Subsistence Rancher Adult	Subsistence Rancher Child
Inhalation (acute risk)	Current	Yes ^a	Yes ^a	Yes ^a	No	No	Yes ^a	Yes ^a
Incidental Ingestion of Soil	Current	Yes	Yes	Yes	No	No	Yes	Yes
Ingestion of Drinking Water from Surface Water Sources	Current	Yes	Yes	No	No	No	Yes	Yes
Incidental Ingestion of Surface Water ^b	Current	No	No	No	Yes	Yes	No	No
Ingestion of Homegrown Produce	Current	Yes	No	No	No	No	Yes	Yes
Ingestion of Homegrown Beef	Current	No	No	No	No	No	Yes	Yes
Ingestion of Homegrown Sheep ^c	Current	No	No	No	No	No	Yes	Yes
Ingestion of Homegrown Goat's Milk ^d	Potential Future	No	No	No	No	No	Yes	Yes
Ingestion of Homegrown Cow's Milk ^e	Potential Future	No	No	No	No	No	Yes	Yes
Ingestion of Homegrown Chicken	Current	No	No	No	No	No	Yes	Yes
Ingestion of Eggs from Homegrown Chickens	Current	No	No	No	No	No	Yes	Yes
Ingestion of Homegrown Pork ^e	Potential Future	No	No	No	No	No	Yes	Yes
Ingestion of Fish ^e	Potential Future	No	No	No	Yes	Yes	No	No
Ingestion of Breast Milk (for dioxins)	Current	No	Yes	Yes ^f	No	No	No	Yes

Notes:

- a The maximum off-site COPC concentration in air will be evaluated for inhalation risk by adult and child residents and adult and child ranchers. The maximum on-site COPC concentration in air will be evaluated for inhalation risk for the on-site worker.
- b Incidental ingestion of surface water during recreational activities (e.g., swimming, boating, and water skiing).
- c Information indicates potentially contaminated mutton may be ingested. This pathway will be quantitatively evaluated if site-specific exposure factors can be identified.
- d Information indicates no known consumption of goat's milk. Therefore, this pathway will be quantitatively evaluated if site-specific exposure factors can be identified.
- e Ingestion of cow's milk, pork, and fish will be evaluated using U.S. EPA (1998a) recommended exposure factors.
- f Exposure to dioxins via ingestion of mother's breast milk will be evaluated for child of on-site depot worker.

Sources: U.S. EPA 1998a; DSHW 1999c

TABLE 4-2

**RATIONALE FOR SELECTION AND QUANTIFICATION OF EXPOSURE PATHWAYS
FOR TOCDF HUMAN HEALTH RISK ASSESSMENT**

Contaminated Medium	Potential Receptors	Potential Exposure Route	Quantify in HHRA?
Air	Resident	Inhalation of ambient air	Yes. Inhalation exposures to adult and child residents assumed to reside at the maximum off-site point of impact for emissions will be quantified.
	Subsistence Rancher		Yes. Inhalation exposures to adult and child ranchers assumed to reside at the maximum off-site point of impact for emissions will be quantified.
	Recreationist		No. Inhalation exposures to adult and child recreationists will not be quantified because the exposures are less than exposures for residents.
	On-Site Depot Worker		Yes. Inhalation exposure will be quantified for on-site depot workers assumed to be located continuously at the maximum on-site point of impact.
	Off-Site Worker		No. Inhalation exposure will not be quantified for off-site workers because exposure will be less than exposure by on-site workers.
Surface Soil	Resident	Incidental ingestion, inhalation of dust, dermal contact	Yes. Ingestion exposures to adults and children who are assumed to reside at the maximum off-site point of impact for emissions will be quantified. Dust inhalation and dermal exposures will not be quantified because these pathways are insignificant sources of exposure when compared to ingestion (U.S. EPA 1998a).
	Subsistence Rancher		Yes. Ingestion exposures to adult and child ranchers who are assumed to reside at the maximum off-site point of impact for emissions will be quantified. Dust inhalation and dermal exposures will not be quantified because these pathways are insignificant sources of exposure when compared to ingestion (U.S. EPA 1998a).
	Recreationist		No. Ingestion exposures to adult and child recreationists will not be quantified because the soil exposures are less frequent than for the resident.
	On-Site Depot Worker		Ingestion exposures will be quantified for DCD workers who are assumed to be exposed at the maximum on-site point of impact for emissions. Dust inhalation and dermal exposures will not be quantified because these pathways are insignificant sources of exposure when compared to ingestion (U.S. EPA 1998a).
	Off-Site Worker		Ingestion exposures to off-site workers will not be quantified because they have less exposure to COPCs than on-site depot workers.

TABLE 4-2 (Continued)

**RATIONALE FOR SELECTION AND QUANTIFICATION OF EXPOSURE PATHWAYS
FOR TOCDF HUMAN HEALTH RISK ASSESSMENT**

Contaminated Medium	Potential Receptors	Potential Exposure Route	Quantify in TOCDF HHRA?
Surface Water	Resident	Ingestion and dermal contact	Ingestion exposures from Soldier Creek drinking water will be quantified for adult and child residents. Dermal exposures will not be evaluated because exposure is considered insignificant when compared to ingestion (U.S. EPA 1998a).
	Subsistence Rancher		Ingestion exposures from Soldier Creek drinking water will be quantified for adult and child ranchers. Dermal exposures will not be evaluated because exposure is considered insignificant when compared to ingestion (U.S. EPA 1998a).
	Recreationist		Incidental ingestion of surface water in SunTen Inc., water ski pond and Rush Lake will be quantified. Exposures from dermal contact are negligible because of the efficiency of the skin as a barrier, the short exposure time, and the low frequency of water contact (U.S. EPA 1998a).
	On-Site Depot Worker		Surface water exposures will not be quantified because the potential for exposures of workers to surface water is considered negligible.
	Off-Site Worker		Surface water exposures will not be quantified because the potential for exposures of workers to surface water is considered negligible.
Homegrown Produce	Resident	Ingestion of homegrown produce	Exposures of adult and child residents who are assumed to grow produce at the maximum off-site point of impact for emissions will be quantified.
	Subsistence Rancher		Exposures of a rancher adult and child who are assumed to grow produce at the maximum off-site point of impact for emissions will be quantified.
	Recreationist		Exposures will not be quantified because the pathway is incomplete.
	On-Site Depot Worker		Ingestion exposures for workers will not be quantified because the pathway will be evaluated for residents and ranchers.
	Off-Site Depot Worker		Ingestion exposures for workers will not be quantified because the pathway will be evaluated for resident and ranchers.

TABLE 4-2 (Continued)

**RATIONALE FOR SELECTION AND QUANTIFICATION OF EXPOSURE PATHWAYS
FOR TOCDF HUMAN HEALTH RISK ASSESSMENT**

Contaminated Medium	Potential Receptors	Potential Exposure Route	Quantify in TOCDF HHRA?
Homegrown Beef, Chicken, Eggs, Pork, Cow's Milk, Mutton, and Goat's Milk	Resident	Ingestion of meat, eggs, and cow's milk (Cont.)	No. Exposures will not be evaluated because residents are assumed to obtain their meat, eggs, and milk from commercial sources. These pathways are also evaluated for the rancher exposure scenarios.
	Subsistence Rancher		Yes. Current ingestion exposures of beef, chicken, and eggs will be quantified for rancher adult and child who are assumed to reside at the maximum off-site point of impact. Ranchers near DCD do not currently consume cow's milk or homegrown pork, so these pathways will be quantified as potential future exposure pathways. Ingestion of mutton will be quantified as a current exposure if exposure factors are identified. Ingestion of goat's milk will be quantified as a potential future exposure if exposure factors are identified.
	Recreationist		No. Ingestion exposures for the recreationist will not be quantified because the pathway is incomplete.
	On-Site Depot Worker		No. Exposures will not be evaluated because workers are assumed to obtain their meat, eggs, and milk from commercial sources. These pathways are also evaluated for the rancher exposure scenarios.
	Off-Site Worker		No. Exposures will not be evaluated because workers are assumed to obtain their meat, eggs, and milk from commercial sources. These pathways are also evaluated for the rancher exposure scenarios.
Fish	Resident	Ingestion of fish	No. Exposures by the resident will not be quantified because the pathway is evaluated for the recreationist.
	Subsistence Rancher		No. Exposures by the subsistence rancher will not be quantified because the pathway will be evaluated for the recreationsist.
	Recreationist		Yes. Exposures from the consumption of fish for adult and children recreationists will be quantified.
	On-Site Depot Worker		No. Ingestion exposures will not be quantified because the pathway is evaluated for the recreationist.
	Off-Site Worker		No. Ingestion exposures will not be quantified because the pathway is evaluated for the recreationist.
Maternal Milk	Infant of Resident	Ingestion of mother's breast milk	Yes. Ingestion exposures to TCDD-TEQs for infants, who are assumed to reside at the maximum off-site point of impact for emissions, will be quantified.
	Infant of Subsistence Rancher		Yes. Ingestion exposures to TCDD-TEQs for infants, who are assumed to reside at the maximum off-site point of impact for emissions, will be quantified.

TABLE 4-2 (Continued)

**RATIONALE FOR SELECTION AND QUANTIFICATION OF EXPOSURE PATHWAYS
FOR TOCDF HUMAN HEALTH RISK ASSESSMENT**

Contaminated Medium	Potential Receptors	Potential Exposure Route	Quantify in TOCDF HHRA?
Maternal Milk (Cont.)	Infant of Recreationist	Ingestion of mother's breast milk (Cont.)	No. Ingestion exposure will not be quantified for because exposure is less than that for the resident.
	Infant of On-Site Depot Worker		Yes. Ingestion exposure will be evaluated for the infant of on-site worker, who is assumed to be exposed to maximum on-site impact.
	Infant of Off-Site Worker		No. Ingestion exposure will not be quantified because the exposure is less than that of resident.

Notes:

DCD	Deseret Chemical Depot
DSHW	Division of Solid and Hazardous Waste
HHRA	Human Health Risk Assessment
TCDD-TEQ	2,3,7,8-Tetrachlorodibenzo(p)dioxin toxic equivalents
TOCDF	Tooele Chemical Agent Disposal Facility
U.S. EPA	U.S. Environmental Protection Agency

Source: DSHW 1999c.

additional pathways), it provides a protective way to account for exposure through potentially important, site-specific pathways.

4.2.2.1 Resident Adult and Child

Several residential areas exist surround the DCD facility. A majority of the population in Tooele County reside in the cities of Tooele (15 miles north of DCD) and Grantsville (21 miles north-northwest of DCD) (ATK 1996). There are also several smaller communities that are within a 6- to 15-mile radius of DCD, including Stockton, Rush Valley, and Ophir. There are currently no residential areas immediately adjacent to DCD or within facility boundaries.

The following current exposure pathways (Table 4-1) will be quantitatively evaluated for the resident adult and child using U.S. EPA (1998a) default exposure factors:

- Inhalation of ambient air (acute risk)
- Incidental ingestion of soil
- Ingestion of drinking water from surface water sources (Soldier Creek)
- Ingestion of homegrown produce
- Ingestion of breast milk (resident child; see Section 4.2.2.5)

Information also indicates that the Army may stock fish in Rainbow Reservoir, which lies within the DCD facility, and open the reservoir to the public for recreational fishing. The fish ingestion pathway will be evaluated for the (non-resident) recreational adult and child. To determine the cumulative impact on residents that fish at Rainbow Reservoir, the risk from the recreational adult and child fish ingestion pathways may be added to the risk from pathways explicitly evaluated for the resident adult and child. Information also indicates that some residents may raise homegrown produce, meat, eggs, and milk. These pathways will be evaluated for the subsistence rancher adult and child (see Section 4.2.2.2), and these results can be used to evaluate these pathways for the resident adult and child. To determine the cumulative impact on residents that may raise homegrown meat, eggs, and milk, the risk for the subsistence rancher may be added to the risk from pathways evaluated for the resident. This total will provide a conservative (overestimation) of cumulative impact because exposure by a subsistence rancher to ingestion of homegrown meat, eggs, and milk factors is substantially higher than exposure by a resident.

Table 4-2 describes the rationale for selecting these pathways and the method for quantifying their exposure. The equations, parameters values, and COPC-specific inputs for these pathways are presented in Appendices E and F.

4.2.2.2 Subsistence Rancher Adult and Child

The subsistence rancher scenario that will be evaluated in the TOCDF HHRA is the same as the subsistence farmer scenario recommended by U.S EPA (1998a). The subsistence rancher exposure scenario more closely represents the ranching activities because most of the land surrounding DCD is currently used for cattle grazing. Portions of land within the DCD facility have been designated for cattle grazing, but no grazing activities have occurred for the last 30 years. Sheep currently graze on land managed by the BLM adjacent to DCD. Alfalfa is raised on irrigated land along the north DCD property boundary. The closest ranching residences are located near the community of Ophir.

The following current exposure pathways (Table 4-1) will be quantitatively evaluated for the subsistence rancher adult and child using U.S. EPA (1998a) default exposure factors:

- Inhalation of ambient air (acute risk)
- Incidental ingestion of soil
- Ingestion of drinking water from surface water sources (Soldier Creek)
- Ingestion of homegrown produce
- Ingestion of homegrown beef
- Ingestion of chicken and eggs
- Ingestion of breast milk (see Section 4.2.2.5)

In addition, DSHW information indicates that homegrown sheep meat (mutton) that is potentially contaminated is consumed in Tooele County. Therefore, the ingestion of mutton will be evaluated as a current pathway. However, exposure factors (exposure frequency and mutton ingestion rate) needed to quantitatively evaluate this pathway are unknown. This pathway will be quantitatively evaluated if the exposure factors can be determined. Otherwise, the pathway will be qualitatively evaluated as an uncertainty.

Available information indicates that several pathways should be evaluated as potential future pathways for the subsistence rancher adult and child (Table 4-1), as follows:

- There is no known consumption of homegrown goat's milk in Tooele County. However, comments on the draft protocol indicate this pathway may be complete. Therefore, ingestion of goat's milk will be evaluated as a reasonable potential future pathway, assuming site-specific exposure factors (exposure frequency and ingestion rate) can be determined. Otherwise, the pathway will be qualitatively evaluated as an uncertainty.
- There is no known consumption of homegrown cow's milk in Tooele County. However, comments on the draft protocol indicate this pathway may be complete. Therefore, ingestion of cow's milk will be evaluated as a reasonable potential future pathway using exposure factors recommended by U.S. EPA (1998a), unless site-specific exposure factors can be determined.
- Information indicates that homegrown pork may be consumed but is not contaminated because their food is not potentially contaminated from emissions from DCD. Therefore, ingestion of homegrown pork will be evaluated as a reasonable potential future pathway using U.S. EPA (1998a) recommended exposure factors.

Information indicates that the Army may stock fish in Rainbow Reservoir, which lies within the DCD facility, and open the reservoir to the public for recreational fishing. The fish ingestion pathway will be evaluated for the (non-resident) recreational adult and child. To determine the impact on residents and subsistence ranchers that fish at Rainbow Reservoir, the risk from the recreational adult and child fish ingestion pathways may be added to the risk from resident and subsistence rancher pathways.

Table 4-2 describes the rationale for selecting and quantifying these pathways. The equations, parameters values, and COPC-specific inputs for these pathways are presented in Appendices E and F.

4.2.2.3 Recreational Adult and Child

The recreational exposure scenario was added for evaluation in the HHRA to address exposures to people that commute to Tooele County for recreation. Recreational activities include fishing, swimming, and windsurfing in Rush Lake; water skiing at the SunTen Inc., facility; and fishing at Rainbow Reservoir at DCD.

The recreational adult and child is assumed to be exposed to COPCs from the emissions sources through the following current pathways:

- Incidental ingestion of surface water from swimming, water skiing, windsurfing, and other water recreational activities
- Ingestion of fish

The potential exposures from the ingestion of surface water and fish will be quantified for Rush Lake, the SunTen Inc., water ski lake (surface water ingestion only), and Rainbow Reservoir (fish ingestion only). Fishing is currently not known to occur at Rush Lake, so fish ingestion will be evaluated as a potential future pathway. Evaluation of the subsistence fisher, as recommended by U.S. EPA (1998a), will not be considered in the HHRA because the fishing activities that occur in Tooele County are recreational, not subsistence. As a conservative approach, the assumptions associated with the ingestion of fish pathway for the recreational exposure scenario are the same as the subsistence fisher scenario as recommended by U.S. EPA (1998a). The results of the assessment of the surface water and fish pathways can be applied to the resident adult and child, and subsistence rancher adult and child, to determine the impact of the fish ingestion pathway on these receptors. Table 4-2 summarizes the rationale for selecting the exposure pathways for the recreational adult and child, and describes how these pathways will be quantified.

The equations, parameter values, and COPC-specific inputs for these pathways are presented in Appendices E and F.

4.2.2.4 On-Site Depot Worker

The on-site depot worker exposure scenario was added for evaluation in the HHRA to address exposure to workers after closure of the facility. Following closure, there will be no source of inhalation exposures except for potential inhalation of re-suspended dust particles. The inclusion of the inhalation pathway is, therefore, a conservative assumption. However, workers may be currently exposed to emissions via inhalation, and infants of female workers may be exposed indirectly through contaminated breast milk. The evaluation of these on-site depot workers at the location of maximum impact for direct and indirect exposures will be protective for both current and potential future depot workers at the DCD facility. Table 4-2 describes the rationale for selecting and quantifying these pathways.

The on-site depot worker is assumed to be exposed to COPCs from the emissions sources through the following pathways:

- Inhalation of ambient air
- Incidental ingestion of surface soil
- Ingestion of breast milk (see Section 4.2.2.5)

The equations, parameters values, and COPC-specific inputs for these pathways are presented in Appendices E and F.

Exposures to the off-site depot worker were initially considered to account for workers that live outside Tooele County and commute to workplaces near the DCD facility. However, the off-site worker will not be evaluated quantitatively in the HHRA because exposures to the on-site depot worker and other off-site receptors are protective of the off-site worker.

4.2.2.5 Breast Milk Pathway

The ingestion of 2,3,7,8-TCDD toxic equivalents (TCDD-TEQ) in breast milk by nursing infants will be evaluated in the HHRA. The breast milk pathway is recommended for evaluation in the TOCDF HHRA because of infant exposures and sensitivity to dioxins. Infant exposure is of potential concern because PCDDs and PCDFs bioaccumulate in lipid and have been detected in breast milk. Infants, on a body weight basis, are potentially exposed to higher doses than adults for the duration of time that they are breastfed. Infants are particularly sensitive to dioxins exposures because 100 percent of their dietary intake comes from breast milk. Infants may also be more toxicologically sensitive to development effects from dioxin exposure.

Infant exposure to dioxins via the ingestion of their mother's breast milk is evaluated as an additional pathway, separately from the recommended exposure scenarios. The breast milk pathway will be quantified for the following exposure scenarios in the TOCDF HHRA:

- Resident
- Subsistence rancher
- On-site depot worker

The breast milk pathway will not be evaluated for the recreationist because exposures for the resident, subsistence rancher, and on-site depot worker would be substantially higher.

Section 8.3 discusses the methodology for evaluating the breast milk pathway and summarizes the major limitations and uncertainties.

4.2.2.6 Acute Exposure from Direct Inhalation

Acute exposure will be evaluated to account for short-term effects of exposure to maximum 1-hour concentrations of COPCs in the emissions (see Section 4.0) through direct inhalation of vapors and particles. The acute effects from direct inhalation of vapor- and particle-phase COPCs will be evaluated for the following exposure scenarios at the point of maximum exposure for their respective land use types:

- On-site depot worker will be evaluated with the maximum on-site COPC concentrations
- Resident will be evaluated with the maximum off-site COPC concentrations

Evaluation of the maximum points of air concentrations for the on-site depot worker and resident are protective because other exposure scenarios have shorter exposure frequencies. The equations, parameters values, and COPC-specific inputs for acute exposure are presented in Appendices E and F.

4.3 ESTIMATION OF EXPOSURE MEDIA CONCENTRATIONS

Media concentrations will be calculated at exposure scenario locations that are selected within a defined land use area and land use type. For example, a residential receptor location is determined by selecting a known residential community within the assessment area. Within this defined area, an evaluation of the magnitude of air parameter values will be made to identify the grid node locations with the highest individual air parameters. Air parameter values specific to the receptor grid node, selected as an exposure scenario location, are then used as inputs to calculate media concentrations to estimate exposure point specific media concentrations. The media concentrations will then be used to quantify risk for each of the recommended exposure pathways specific to each exposure scenario.

The exposure media concentration calculations will be performed in accordance with U.S. EPA (1998a). The risk assessment software, IRAP-*h* VIEW[®], will be used to perform the calculations (Lakes Environmental Software, Inc. [Lakes] 1999). The equations discussed are those used to calculate COPC concentrations in air from direct inhalation, soil from incidental ingestion, surface water from incidental ingestion and direct contact, produce from ingestion, animal products from ingestion, and fish from ingestion.

All of the exposure media concentration equations that will be used in the HHRA are referenced in Appendix E of this protocol.

4.3.1 Ambient Air Concentrations

The ambient air concentration equation (see Equation E-5-1) calculates the air concentration of a COPC based on the fraction in vapor phase and the fraction in particle phase (U.S. EPA 1998a). To account for mercury speciation, air concentrations are calculated by multiplying the COPC-specific emission rate by 0.0002 for elemental mercury and 0.48 for divalent mercury. The fraction of COPC air concentration in the vapor phase also accounts for mercury speciation by assuming that the vapor phase is 1.0 for elemental mercury and 0.85 for divalent mercury.

4.3.2 Surface Soil Concentrations

The surface soil concentration equations calculate the COPC concentrations due to deposition that potentially contaminates homegrown produce, animal products, drinking water, and fish (see Equations E-1-1, E-2-1, E-3-1, and E-4-1). The equation calculates an average COPC concentration resulting from wet and dry deposition of particles and vapors to soil over the exposure duration (U.S. EPA 1998a). COPCs are assumed to be incorporated only to a finite depth (the mixing zone depth).

4.3.3 Surface Water Concentrations

The surface water concentration equation (see Equation E-4-24) calculates the dissolved phase water concentration. For mercury modeling, the total water body concentration is calculated for divalent mercury and methyl mercury by using their specific input parameters.

4.3.4 Homegrown Produce Concentrations

The homegrown produce concentration equations (see Equations E-2-7 through E-2-10) evaluate both aboveground produce and belowground produce. The COPC concentration in aboveground produce will be calculated due to direct deposition, air-to-plant transfer, and root uptake. The COPC concentration in belowground produce will be calculated due to root uptake only.

4.3.5 Meat, Milk, and Eggs Concentrations

COPC concentrations will be calculated for beef, pork, mutton, milk, eggs, and chicken (see Equations E-3-10 through E-3-14). The animal equations estimate the daily amount of COPCs taken up through the ingestion of contaminated plant and soil material. The equations then recommend the use of biotransfer factors to transform the daily animal intake of a COPC (milligram per COPC per day [mg/COPC/day]) into an animal COPC tissue concentration (milligram of COPC per kilogram of fresh weight tissue [mg COPC/kg FW tissue]).

4.3.6 Fish Concentrations

COPC concentrations will be calculated for fish from bioconcentration factors or bioaccumulation factors using dissolved phase water concentrations (see Equations E-4-26 and E-4-27). For mercury modeling, total water column concentrations for methyl mercury and divalent mercury will be applied to the equations.